International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056
Volume: 03 Issue: 04 | Apr-2016 www.irjet.net p-ISSN: 2395-0072

POWER FACTOR CORRECTION USING BRIDGELESS ISOLATED-CUK CONVERTER

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ABSTRACT: *The objective of this paper presents a power factor correction based bridgeless isolated Cuk converter fed brushless DC motor drive. A DC link voltage feeding BLDC motor is used for its speed control. This allows the operation of VSI in fundamental frequency switching. Therefore an electronic commutation of BLDC motor is achieved, As a result it reduces switching losses. By eliminating the front end diode bridge rectifier conduction losses can be reduced. The proposed method is designed to operate in discontinuous inductor current mode to achieve the unity power factor. Here the single voltage sensor is used in order to reduce the total cost . An improved power quality is achieved at AC mains with power quality indices within limits of IEC 61000-3-2 standard.*

***Index Terms*: BLDC Motor, Bridgeless Isolated Cuk Converter, Discontinuous Inductor Current Mode, Power Factor Correction, Power Quality, Voltage Source Inverter.**

I. INTRODUCTION

Power factor correction (PFC) converters are used to avoid power quality problems at the AC mains and to meet the prescribed guidelines of IEC 61000-3-2. The sensing requirement of this PFC converter plays major role in deciding the cost of overall system. The required number of sensors for a PFC converter is primarily decided by its mode of operation of the PFC converter. Continuous inductor current mode (CICM) and discontinuous inductor current mode (DICM) are two modes of operation of the PFC converter. In CICM, or continuous conduction mode (CCM), the current in inductor remains continuous in a switching period, whereas the current becomes discontinuous in a switching period for a PFC converter operating in DICM. The PFC converter operating in CICM uses a current multiplier approach for voltage control and power factor correction. It has lower current stress on the PFC converter switch but requires three sensors for its operation. However, a single voltage sensor is used for a PFC converter operating in DICM using voltage follower approach, but at the cost of high current stress on the PFC converter switches. Therefore, this mode of operation is suited for low power applications.

II.EXISTING SYSTEM

A Voltage source inverter fed BLDC motor drive is supplied by a combination of a diode bridge rectifier with a high value of smoothening DC link capacitor. This

combination draws current only for a small duration when the instantaneous value of supply voltage is higher than the DC link voltage. Therefore, a peaky current is drawn from the AC mains, which increases the harmonic contents. The total harmonic distortion of such current is of the order of 60-80 % which leads to a very poor factor of the order of 0.6-0.7 at AC mains. Such power quality indices are not acceptable under the limits of international power quality standard IEC 61000-3-2. By using sensor in this motor the cost can be increased to the high value .this is the main drawback in this BLDC motor. Due to operation of BLDC motor in high switching frequency switching losses can also be increased. This losses can be reduced by operating this motor in low switching frequency. The existing system (buck- boost) converter have low voltage conversion ratio. This conversion cannot be used to control the speed at the ac mains. In order to overcome these above problems we are using bridgeless isolated cuk converter.

III.PROPOSED METHOD

PFC BRIDGELESS ISOLATED-CUK CONVERTER :

In this proposed system the single-phase supply followed by a LC-filter is used to feed a bridgeless isolated-Cuk converter. Therefore the DC link voltage of the VSI and provides power factor correction at AC mains. This converter operates in discontinuous inductor current mode to act as an inherent power factor corrector.

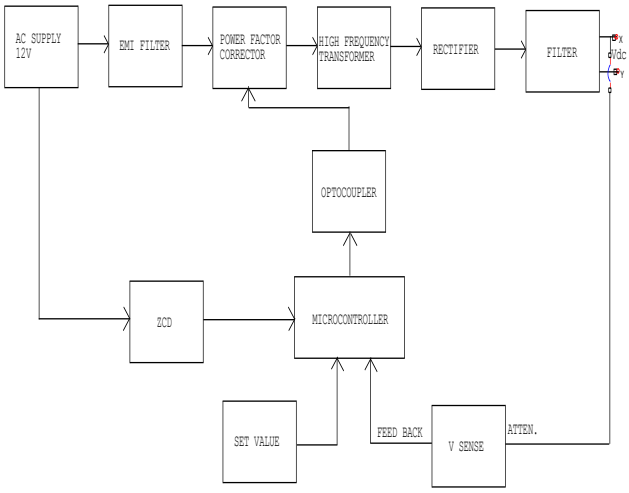

Fig 3.1 Block diagram

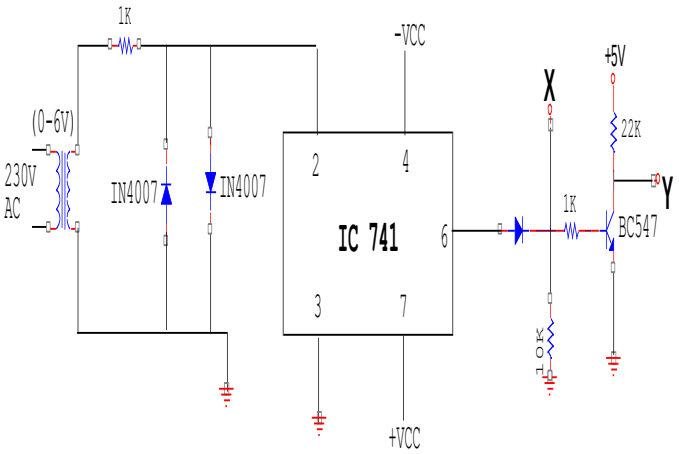

Fig 4.1.1 circuit diagram

Because of using a single voltage sensor to control the DC link voltage for control of output voltage. The proposed drive is designed and its performance is validated on a developed prototype for improved power quality.

IV. BLOCK DIAGRAM DESCRIPTION

ZERO-CROSSING DETECTOR:

Zero-crossing detector is same as the comparator. The op-amp comparator circuits can be used as the zero-crossing detector which provides the reference voltage V_{ref} is made zero. The output voltage waveform indicates direction in which the input signal v_{in} crosses zero volt. It is also called "sine to square wave generator.

When the input is positive pulse the non inverting terminal is less than at the inverting terminal. Hence the output from LM741 comparator is $-V_{sat.}$ This signal will be given to the BASE of BC547.

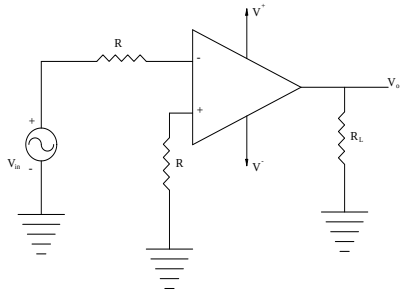

Fig 4.1.2 Zero cross detector

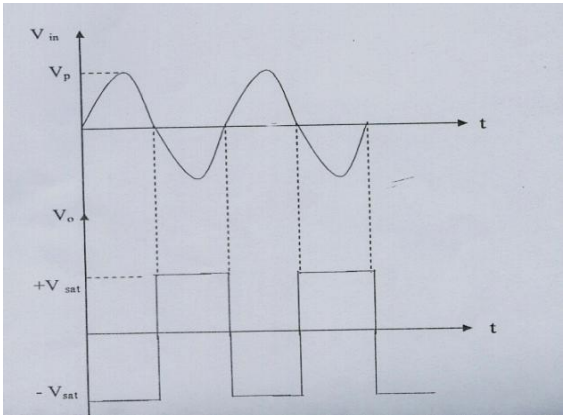

Fig.4.1.3 Output Waveform

Hence the output from collector of transistor is 1.When the input is negative pulse the inverting terminal is less than at the non inverting terminal. Hence the output from LM741 comparator is $+V_{sat.}$ This signal will be given to the base of BC547. Hence the output from collector of transistor is 0.

4.2. MICROCONTROLLER:

Micro controller is a device which performs the small instruction that can be already programmed in it. Some of the core features are

- Single 5V In-Circuit Serial Programming capability
- Processor read/write access to program memory

4.3.OPTOCOUPLER:

Optocoupler IC MCT2E provides an isolation between control circuits and power circuits. It allows signal transfer without coupling wires or capacitor. There is no electrical contact between these two two circuits.

Optocoupler transducers the input voltage to proportional light intensity with the help of LEDs. It not only separates the high voltage input side and the microcontroller but also prevents the microcontroller from damage and noisy operations. It also reduces the unwanted noise that can be produced in the system.

4.4. APPLICATIONS:

- Utility /economy isolator
- AC line / digital logic isolator
- Digital logic /digital logic isolator
- Telephone line receiver
- Telegraph line receiver
- Twisted pair line receiver
- Relay contact monitor

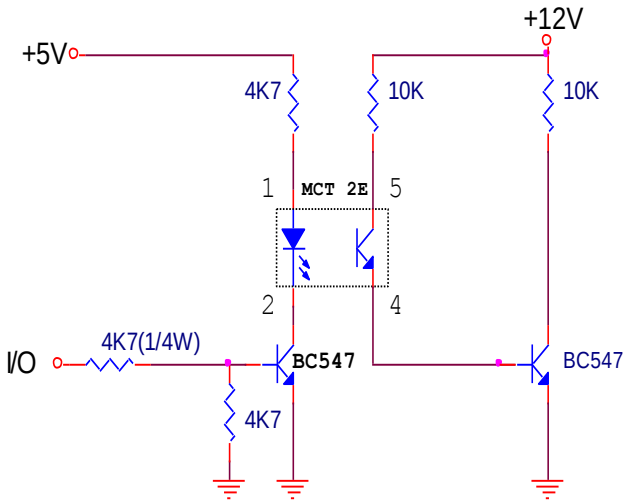

Fig 4.1.4 Optocoupler

4.5.NEED FOR AN OPTOCOUPLER:

The main advantages of this optocoupler is to separate the high voltage input side and the microcontroller. It prevents the microcontroller from damage because of this line voltage transistor. It reduces electrical noise that is common in industrial environments. This electrical noises can cause erratic operation of the microcontroller.

4.6.WORKING PRINCIPLE:

The supply voltage ac 230v is step down to 9 volt, using 9v step down transformer. Electromagnetic interferences are produced in the supply voltage. These interferences and harmonics can be eliminated by using EMI filter. The filtered output is fed into the power factor corrector. Another input to the PFC is fed from the microcontroller in order to control the switching operation. The low value secondary voltage is fed to the rectifier is formed using four no. of IN 4007.

The output from the rectifier is again filtered. This output voltage is compared with the reference set value in the microcontroller. The input ac voltage can be converted into dc by using zero coss detector and it is fed to the microcontroller. By using these three signals the microcontroller controls the operations of switches in PFC

During first half cycle, Diodes D1 & D2 come to action and next half cycle diode D3 & D4 come to actionAs a result the unidirectional current can be produced. The charging & discharging property of capacitor is used for smoothening the

output voltage. This pure DC supply is usually fed to regulator IC's input terminal. Because of this regulator action, finally, regulated 5 volts can be produced at the output terminals. This supply is used for entire circuit.

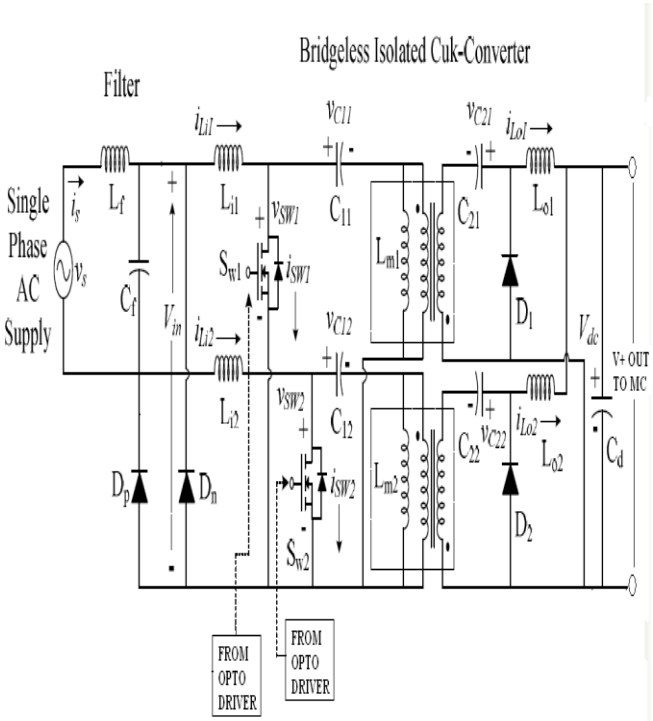

Fig 4.1.5 Circuit Diagram

V.MOSFET (IRF840)

A MOSFET is a voltage controlled 4 terminal devices. There are three main terminals and a substrate terminal. The three main terminals are the Drain, the Source and the Gate. Of the MOSFET family there are two main members and they are the Depletion MOSFET and the Enhancement MOSFET.

The study the characteristics of the MOSFET it is convenient to look at the device as a black box that has two terminals on the input side and two terminals on the output side sharing one terminal as common for both the input and the output sides.

The MOSFET when used as an amplifier the small signal is applied to the respective terminals of the black box while the amplified output is available at the two output terminals.

Depending upon the terminal that is kept common to the input and output sides the configurations are named as common Source, common Drain or common gate configurations.

In the common Source configuration the input signal is applied across the Gate and the Source terminals. The output is derived across the Drain and the Source terminals.

Characteristics of any system in general, are nothing but the behavior of the system, monitored in terms of its response for every excitation applied to it. The excitation is the voltage applied to the device and the response is the current caused by the voltage. Thus the device shows different currents for different applied voltages.

5.1.TRANSIENT CHARACTERISTICS:

Transistors characteristics are studied as input characteristics and output characteristics. The response on the input side itself for different excitations made on the input side is called the input characteristics. Similarly the response on the output side for different excitations on the output side itself is called the output characteristic.

When the device is excited from one side while its response on the other side is observed then the response with respect to the excitation from the other side is known as the transfer characteristics

VI.POWER SUPPLIES FOR MOSFETS

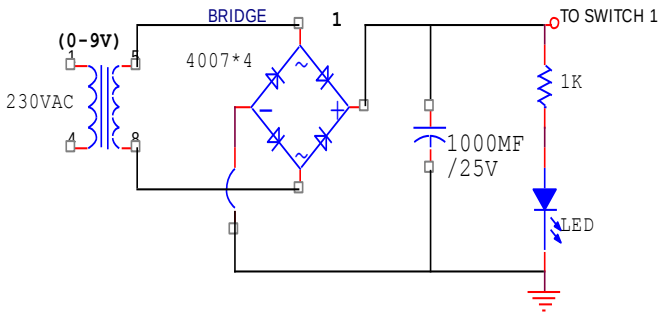

Fig 6.1 MOSFET power supply

6.1 ADVANTAGES:

- Switching time is about 10 times faster.
- High switching speed,low switching loss.
- Simple gate drive circuit.
- Very much smaller switching current.
- Less affected by temperature.

VII.PULSE-WIDTH MODULATION (PWM)

Pulse width Modulation is the circuit which is used to control the analogue circuit. it uses a square wave in which the duty cycle is modulated, as a result the output waveform can be changed.PWM reduces the total amount of power that can be transmitted to the load so that the losses can be eliminated. The on/off states of modulation is used to control the state of switch thereby correspondingly controls the flow of voltage or current that can passed through the load. The advantages is that the pulse width modulation circuit does not conduct any current and thereby voltage drop does not occurs in the system.

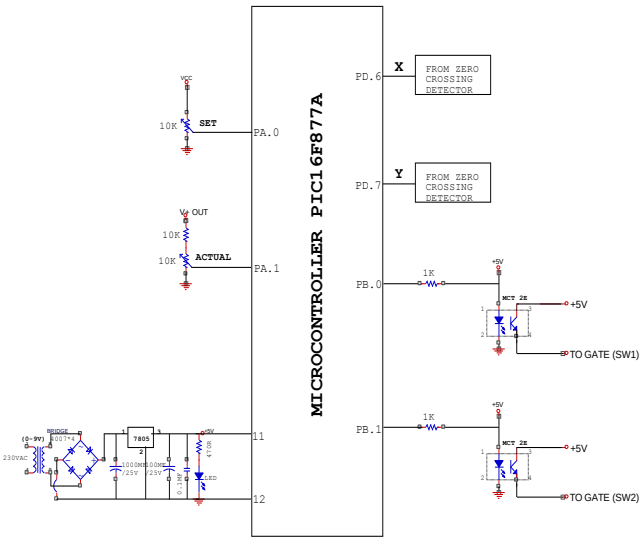

Fig 7.1 Control circuit

7.1 FEATURES:

- High performance RISC CPU
- Only 35 single word instructions to learn
- All single cycle instructions except for program
- Branches which are two cycle
- Operating speed: DC - 20 MHz clock input
- DC - 200 ns instruction cycle
- Interrupt capability (up to 14 sources)
- Eight level deep hardware stack
- Direct, indirect and relative addressing modes
- Power-on Reset (POR)
- Programmable code protection
- Power saving SLEEP mode

VIII.PERIPHERAL FEATURES

- Timer0: 8-bit timer/counter with 8-bit pre scalar
- Timer1: 16-bit timer/counter with pre scalar
- Can be incremented during SLEEP via external
- Crystal/clock
- Timer2: 8-bit timer/counter with 8-bit period
- Register, pre scalar and post scalar
- Two Capture, Compare, PWM modules
    1. Capture is 16-bit, max. resolution is 12.5 ns
    2. Compare is 16-bit, max. resolution is 200 ns
    3. PWM max. resolution is 10-bit
- 10-bit multi-channel Analog-to-Digital converter.

XI.CONCLUSION

A new configuration of bridgeless isolated cuk converter fed BLDC motor drive has been proposed for low power threshold appliances. This proposed system reduces a conduction losses and switching losses.

The speed control of BLDC motor has been achieved by controlling the DC link voltages of VSI fed BLDC motor. This PFC converter has been operated in DICM for DC link voltages control and inherent power factor correction is achieved at the AC mains. By operating this motor in discontinuous inductor current mode the total cost of this system can be reduced . The output voltage and current waveform are maintained in phase so therefore unity power factor can be achieved .

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